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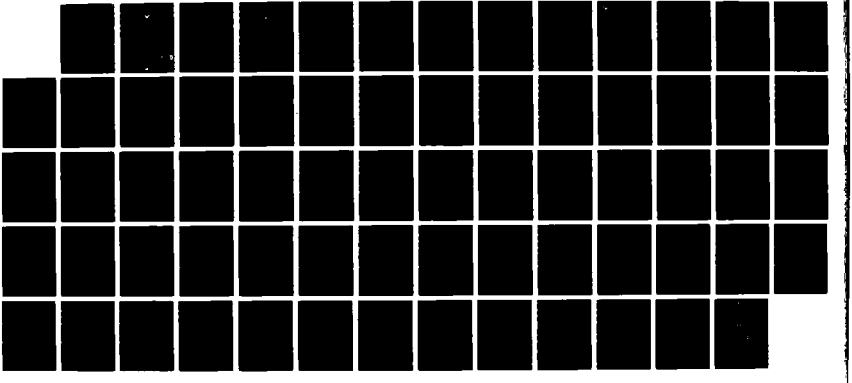

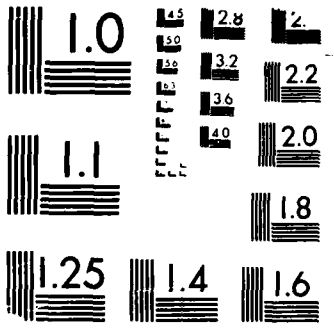

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AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT

THE PRINCIPLES OF MASS AND MANEUVER APPLIED TO SPACE OPERATIONS

MAJOR EDWARD F. TEIGELER 88-2540

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TITLE THE PRINCIPLES OF MASS AND MANEUVER APPLIED TO SPACE OPERATIONS

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Military space doctrine development has received considerable attention on how the principles of war apply to space operations. Many have argued that the principles of mass and maneuver do not apply, or that they apply only in a very narrow sense. This study examines what the principles of war could bring to the development of military space doctrine, and analyzes recent positions on the applicability of mass and maneuver. The report concludes that the present positions on mass and maneuver are based on too limited a definition of both principles, were considered only for the space segment, and used too narrow a definition of the theater of operations for space warfare. The report provides a summary of the concepts which make up mass and maneuver, and a space force structure for use in applying the principles.

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PREFACE

The work of developing military space doctrine has continued since the initial publication of Air Force Manual 1-6 in October, 1982. One area which has received considerable attention has been on whether or not, or how the principles of war apply to space operations. Due to the space environment and the characteristics of space operations, many have argued that some of the principles do not apply, or that they must be conceptually changed or limited for application to space warfare. The principles of mass and maneuver are two of the most controversial. Yet, military theorists throughout history have indicated that mass holds the key to victory, and maneuver is the means to achieve it. Before the final verdict of, at most, a limited acceptance of these principles is made, an exhaustive look at these principles and how they might apply to space operations ought to made. This paper takes that comprehensive look and concludes that mass and maneuver, when understood in full and applied broadly to space operations, apply as much to warfare in space as in any other medium.

This material is being submitted to the faculty of the Air Force Institute of Technology in partial fulfillment of the requirements for the Master of Science in Space Operations degree.

The initial results of this study were presented at the Air Force Space Doctrine Symposium, 4-6 November 1985, at Headquarters Space Command, and have been referenced by Commander Hartzell in a paper prepared for the National War College. This paper goes greatly beyond those initial results as briefed.

I would like to acknowledge the support and thank the many individuals, friends, and classmates who supported me during the preparation of this report. I particularly thank Colonel Mark Mekaru, my thesis advisor at AFIT, and Major Bruce Thieman, my advisor at ACSC, for their patience, understanding, and support. I am especially grateful for the assistance provided by Lieutenant Colonel Greg Parnell at AFIT. Finally, I want to thank Joanne, my wife, for her loving support and, somehow, putting up with me during the preparation of this report.

ABOUT THE AUTHOR

Major Edward F. Teigeler, III graduated from the United States Air Force Academy in 1974 with a Bachelor of Science degree with a major in history. He was initially assigned to the 91st Strategic Missile Wing at Minot AFB, North Dakota, as a missile combat crew member. In 1979, Major Teigeler was assigned to the 1st Strategic Aerospace Division at Vandenburg AFB, California, in PROJECT TOPHAND. Assigned to the Test Operations Division, he conducted Minuteman ICBM operational test launches. Major Teigeler attended the first graduate space operations class at the Air Force Institute of Technology from 1981 to 1982. His next assignment was to the Air Force Operational Test and Evaluation Center (AFOTEC) at Kirtland AFB, New Mexico, as a space operations analyst. While at AFOTEC, Major Teigeler was the lead operational effectiveness analyst for planning the multiservice initial operational test and evaluation (IOT&E) of Milstar. Milstar, a new communications satellite, is the first space system designed from the start for war fighting survivability. The Milstar IOT&E will evaluate the operational effectiveness of the space, mission control, and terminal segments with special emphasis on the advanced communications performance, distributed control capabilities, and advanced survivability measures. His decorations include the Meritorious Service Medal with first oak leaf cluster and the Air Force Commendation Medal. Major Teigeler is married to the former Joanne M. Harman of Reading, Pennsylvania. They have two children, Edward and Amanda.

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"insights into tomorrow"

REPORT NUMBER 88-2540

AUTHOR(S) MAJOR EDWARD F. TEIGELER, III, USAF

TITLE THE PRINCIPLES OF MASS AND MANEUVER APPLIED TO SPACE OPERATIONS

I. Purpose: Do the principles of mass and maneuver apply to space operations, and if so what insights do they provide for the development of military space doctrine?

II. Problem: The principles of mass and maneuver have gained only very limited and partial acceptance for application to space operations, despite their validity, if not preeminence, in other forms of warfare. The controversial or qualified acceptance of the principles of mass and maneuver would indicate either a problem with the analysis for their application, or that the space environment is simply so unique that the application of fundamental beliefs about warfare must be changed to incorporate space operations. Either of these possibilities indicates a need for great caution. Before the final verdict is made, a comprehensive examination of these principles and how they might apply to space operations is warranted.

III. Data: The principles of war were examined to determine what they were and how they could contribute to the development of space doctrine. There is no universally agreed upon list of principles, and beyond a few phrases there is considerable variation in what constitutes any particular principle depending upon the level of warfare considered and the division of a greater number of recurring key concepts among the principles.

The principles of war are not immutable laws by which military forces must act, but, at best, provide a framework for the critical analysis of military operations with a warning that an understanding beyond a few phrases is required. The reports on the applicability of mass and maneuver were reviewed. In general, both principles are viewed as having very limited application to space operations. The tremendous energy requirements to make even small changes in a satellite's orbit negates maneuver, and without maneuver there can be no collocation of forces. Instead, deployability and pointability replace maneuver, and directed energy weapons are targeted against a common point for mass. The principles of mass and maneuver were examined in great detail using a wide variety of sources to determine if mass and maneuver were correctly applied. A major problem, unforeseen in this effort, was the need to develop full definitions of principles of mass and maneuver which would account for the variations seen among the many theorists and levels of warfare. Under comparative analysis both the principles converged into five concepts each. Finally, the composition, functioning, and vulnerabilities of space forces and the space theater of war were examined and compared to the previous reports on mass and maneuver.

IV. Conclusions: The previous reports' conclusions on the applicability of mass and maneuver are in error. The cause for this is based upon their using too limited a definition of both mass and maneuver, applying the principles only to the space segment, and limiting the space theater of war to only the near earth orbits used today. Both principles were far more substantial that the applications made thus far to space operations, applying to all levels of warfare. Both principles converged into five concepts each. Militarily, mass is the concentration of destructive combat power at the decisive point and time. The means to attain mass were explained under the following five concepts: (1) thoroughly and accurately plan the operation, (2) correctly select the decisive region, axis, and point, (3) strategically use all available forces simultaneously, (4) distribute the force according to its various capabilities and the threat to bring a superiority of combat power to the decisive point, and (5) relentlessly and courageously pursue the attack against the decisive point for shock and momentum--create a superiority of morale. Maneuver is the adaptable commitment of national power resources at all levels of warfare against a responsive enemy in order to gain an ever more advantageous position. The five general concepts which together seem to constitute the principle of maneuver are: (1) maneuver to obtain mass; (2) create and use a mobile reserve; (3) seek the highest possible level of mobility; (4) minimize the observation,

decision, and implementation cycle time; and (5) maintain flexibility of thought, plans, and operations. The broad definitions of mass and maneuver presented here offer the possibility of considerably more insight into what the nature of space warfare may involve. Space systems work together in an interdependent space architecture, and individually can be broken down into space, control, user, communications links, and logistics segments. The negation of any segment will eventually negate the system. This structure implies differing nodal vulnerabilities for determining decisive points for space warfare, and thus the application of mass. Further, the use of mobile ground systems to counter vulnerabilities in the control and user segments indicates the need to reconsider maneuver.

V. Recommendations: First, complete this study by summarizing the space theater of war and then applying each of the five concepts of mass and maneuver to the use of space systems under the strategic, operational, and tactical levels of warfare. Second, perform a comparative analysis of the other principles of war to make them a far more valuable tool in understanding warfare. Finally, assuming such a comparative analysis of the principles of war is made, incorporate the results into current doctrine with modification of both Army Field Manual 100-5 and Air Force Manual 1-1.

Chapter One

INTRODUCTION

One of the primary interests in the evolution of space doctrine has been the applicability of the principles of war. Simple logic would say the principles of war have proven to apply to all warfare thus far, whether it be land, sea, air, or combined warfare. Warfare in space is still warfare. The principles of war should therefore apply to military space operations. In general, the principles of war have been accepted by those working with space doctrine, but generally with modifications to adapt them to the space environment. However, two of the principles, mass and maneuver, have been quite controversial. They have gained only very limited and partial acceptance for application to space operations, despite their acceptance, if not preeminence, in other forms of warfare.

The controversial or qualified acceptance of the principles of mass and maneuver would indicate either a problem with the analysis for their application, or that the space environment is simply so unique that the application of fundamental beliefs about warfare must be changed to incorporate space operations. Either of these possibilities indicates a need for great caution. Before the final verdict is made, a comprehensive examination of these principles and how they might apply to space operations is warranted. This report documents such an examination. The background, problem, scope, general approach, and sequence of presentation for the report are provided first.

BACKGROUND

The development of military space doctrine began strongly in the late 1950's, ebbed during the 1960's and most of the 1970's, and re-emerged in the late 1970's. In the United States, early advocates of space doctrine included General Thomas D. White (38:--; 39:--; 41:5; 50:25-31) and General Bernard A. Schriever (41:2). Intercontinental ballistic missiles (ICBMs) and our other current space systems were developed and integrated into military operations with little change to airpower doctrine through the concept of the indivisibility of air and space (38:41). During the 1960's and the early 1970's, military thought within the United States was focused upon the development of nuclear deterrence theory and low intensity conflict. Very

little concerning space doctrine was published during this period. Space systems were developed with space essentially regarded as a sanctuary based upon a space policy of the non-militarization of space (24:45). However, technological advancement resulted in space systems becoming vital to terrestrial operations through the force enhancement functions of communication, navigation, surveillance, and reconnaissance. Further, the push of technology opened up new possibilities for moving warfare into space with anti-satellite (ASAT) weapons and advances in directed energy systems (24:45-47).

To cope with the increasingly vital contributions of space systems to terrestrial forces, the Soviet ASAT, and potential implications of directed energy weapons, military thought in the United States again focused in the late 1970's on the development of space doctrine (23:--; 26:--; 32:--; 33:--; 35:--). Culminating the initial efforts were the United States Air Force Academy Military Space Doctrine Symposium, 1-3 April 1981 (44:--; 45:--), and the first publication of Air Force Manual 1-6 (AFM 1-6), Military Space Doctrine, on 15 October 1982 (41:--). These two events seem to have initiated a sustained interest in the development of military space doctrine and strategy. Following these two events, the development of space doctrine and strategy has continued with several subsequent symposiums, critiques and suggested rewrites of AFM 1-6 (54:--), numerous research projects from professional military schools, and several drafts of a proposed AFM 2-XK, Aerospace Operational Doctrine: Space Operations (55:--; 56:--).

PROBLEM

The question for this project is: Do the principles of mass and maneuver apply to space operations, and if so what insights do they provide for the development of military space doctrine?

SCOPE

Several important considerations limit the scope of this report. The first of these considerations was to keep the report unclassified. This decision was made to allow for wider distribution of the report. Military doctrine and the support behind it should receive the widest possible distribution to be effective. Research specifically for this report was limited to unclassified sources only. Military space systems and future planning for space operations, however, are heavily classified. More specific, accurate, and authoritative sources are in some instances available only at the classified level. Even so, the level of detail at the unclassified level appears to be adequate for this investigation.

The second consideration for this report was to focus only

on implications which would apply only to environmental doctrine, as opposed to fundamental or organizational doctrine. Fundamental doctrine consists of relatively unchanging basic beliefs about the purpose, nature, and conduct of war. The principles of war are included in fundamental doctrine. Environmental doctrine consists of beliefs about how to best conduct war with either land, sea, air, or space forces using foreseeable technology. Organizational doctrine is concerned with how to best organize and fight a specific force (such as the United States Air Force) in one of the mediums, with present capabilities (40:145-147).

The third consideration was that political and fiscal constraints were not to be considered. This decision was based upon a number of reasons. This report is concerned with doctrine and not strategy. Doctrine should define the best ways to conduct military operations. As such, doctrine becomes a significant input into the strategy process to support the achievement of specific national objectives. Other inputs to the strategy process include economics, domestic politics, and international politics (40:12-22). Thus, current national and international policy were not taken into account. Any nation in formulating a strategy will be limited by the means at its disposal and the political limitations which it accepts. Inclusion of any concepts contrary to current national policy or any international agreement is not meant to advocate a change or a deficiency in policy.

GENERAL APPROACH

The research for this paper sought initially to understand how the principles of war might contribute to the development of space doctrine, then to understand the principles of mass and maneuver in great detail, and finally to understand the factors which were important to warfare in space. With that background, current documents on space doctrine and strategy were researched to determine current opinions on whether mass and maneuver apply to space operations. The current beliefs on massing and maneuver of space forces were then analyzed to see if they incorporated all the issues and factors related to these two principles and the nature of military space operations.

SEQUENCE OF PRESENTATION

This report contains six chapters, including this introduction. In Chapter Two the report first establishes a basic understanding of what the principles of war are and how they might be used. Chapter Three then examines how mass and maneuver are believed to apply to space operations today. Three major deficiencies seem to have led to only limited acceptance of mass and maneuver for the conduct of military operations with

space systems. First, the principles applied from AFM 1-1, Basic Aerospace Doctrine of the United States Air Force, were too narrowly defined, and did not include all the concepts traditionally contained within the principles of mass and maneuver. Secondly, the principles were applied only to satellites instead of space systems working within an interdependent space architecture and consisting of various segments. Finally, the principles were applied in general only to near earth orbits and deep space storage orbits, as opposed to a wider space theater of war. Chapter Four defines the principles of mass and maneuver, developing their major concepts from the works of major military theorists. Chapter Five describes how space systems work together in a space architecture, are made up of different segments, and are subject to numerous threats. Chapter Six contains the summary and recommendations.

Chapter Two

HOW CAN THE PRINCIPLES OF WAR APPLY TO SPACE OPERATIONS?

INTRODUCTION

This chapter explains what the principles of war in general are, and how they might contribute to the development of space doctrine. The principles of war, as part of the art of war, are the condensed lessons of military history. Beginning with Clausewitz (2:--), they are generalizations of a central core of concepts that have worked well for military commanders in the past. There is no universally agreed upon list of principles, but rather numerous different lists of principles used by different authors, nations, and even the services within the armed forces of the United States. These different lists of principles use different combinations of the many key concepts which complicates their understanding and use. Their understanding is further complicated by the way the principles work inseparably together making consideration of any single principle to a given problem more difficult. Taken together, the principles of war do not describe the ways in which military forces must invariably act, but provide general considerations which must be traded off with each other in the conduct of any specific operation. As for how the principles of war might be used, three individuals, Holley (28:--; 29:--; 30:--), Starry (36:--), and Collins (5:--) provide some guidance. They do not provide ready-made answers to a given problem. At best the principles of war provide only small sparks of imagination for the planning of military operations. Their chief value is in providing a framework for the critical analysis of military operations. The weight of opinion is that the principles of war are deserving of consideration, but with the warning that an understanding beyond a few phrases is required.

THE PRINCIPLES OF WAR

The writings of military theorists, in their analysis of history and attempts to grapple with the problems of war in their time, can be broken down into the art and the science of warfare. The science of war, driven by technology, speaks of the weapons and organizations of the time, and the ways in which they can be used (strategy and tactics) to gain victory. The art of war

looks to that part of war which transcends the element of time--the technology, organizations, and tactics of the moment. It looks to what is fundamental in the conduct of war, and is derived from critical historical analysis of warfare (36:4). The principles of war are a part of the art of war available for general application today. While based on history, the principles of war are actually relatively new.

The principles of war, developed only within the past two hundred years, seek to generalize the many major recurring concepts used in the past for winning wars. Napolean noted that, "Gustavus Adolphus, Turenne and Frederic, as also Alexander, Hannibal and Caesar have all acted on the same principles" (16:431-432). However, these warriors did not leave behind, in the books about their campaigns, the principles by which they fought. Napolean himself did not leave behind his principles, leaving others to collect his maxims. The first listing of specific principles of war was made by Clausewitz in 1812 (5:22). Other significant early authors of various lists of principles of war include Mahan, Foch, and Fuller (5:22). The principles of war are generalizations by these and other theorists about the key precepts which successful military commanders have worked to achieve in their operations. Some of these principles are mass, maneuver, economy of force, surprise, security, and so on. Often the explanations of the principles are done within the context of the historical conditions of time--the weapons, formations, transportation, and communications which were available. These few principles, however, must deal with war in all its complexity, resulting in different lists of principles, different definitions of principles between authors, and whole books being written to explain one man's concept of a list of principles.

The principles of war do indeed differ between different authors, different times with the same author, and different nations. Figure 1 provides a comparison of the principles developed by several authors. Sun Tzu did not actually list principles of war (20:--). However, his precepts fit some of the principles shown. Foch lists only the four principles of war shown; however, he suggests additional principles (7:8). In actuality, Foch uses most of the other principles shown, but includes them within his principle of economy of force (7:44-47, Chapter III). Two of Fuller's lists are shown. The first list contains eight principles from his book, The Reformation of War, published in 1923 (9:--). The second list is from his book, The Conduct of War, 1789 - 1961, published in 1961 (8:--). The latter deletes the principle of cooperation, and uses different terms for five of the remaining seven principles. This initial diversity on the structure and content of the principles of war has continued. Figure 2 provides a comparison of the principles used by several nations. Even within the United States, different principles are used by the Army and the Air Force.

Another problem is that within the United States Air Force,

the principles of war, as contained in the last three editions of AFM 1-1, have changed significantly within the past ten years. Figure 3 shows the evolution of the principles of war within Air Force doctrine. In 1979, the Air Force incorporated the principles of maneuver, simplicity, and timing and tempo (43:5-5 - 5-8). In 1984, the Air Force added the principles of logistics and cohesion, while eliminating the principle of the defensive. The Air Force also returned to a more classical definition of economy of force which emphasizes a minimum allocation of forces to secondary objectives to enable the greatest possible force at the decisive point. Additionally, as in two previous editions, economy of force was discussed together with mass which highlights a further complication with the principles of war (42:2-5 - 2-10).

The principles of war are interdependent and interrelated making consideration of any single principle to a given problem more difficult. Starry notes, "No single principle can be blindly adhered to or observed to the exclusion of the others, and none can assure victory in battle without reinforcement from one or more of the others" (36:12). Maneuver provides the means to achieve mass. Mass at the critical time and place allows achievement of the objective. Economy of force ensures the greatest mass possible while securing the massed force against surprise. Surprise enables a commander to maintain or seize the offensive. Unity of command allows the coordination of all forces involved leading to the best possible economy of force. In any particular situation the principles of war have existed within an ever changing relationship with each other and the conditions of the moment. For Fuller, some of the most important of many conditions were, "Time, space, ground, weather, numbers, training, communications, supply, armament, formations, obstacles and observation" (9:40). An appreciation of the relationships between the principles is therefore required since they do not work in isolation. Additionally, an appreciation of the effect of conditions upon their application is required (37:41).

Even when the relationships of the principles and an understanding of the effects of conditions are known, the principles of war will be found lacking or of questionable value by many. The principles of war do not describe the manner in which military forces must invariably act; they are not inviolate laws of nature such as found in physics. The principles of war will offer no immediate solutions to particular problems. Clausewitz, acknowledged as probably the greatest philosopher on war, felt that war was too complicated an event to be modeled into a structure which could be depended upon at any time (3:140). Liddell Hart said,

> . . . the modern tendency has been to search for principles [of war] which can each be expressed in a single word--and then need several thousand words to explain them. Even so, these 'principles' are so

Sun Tzu (5:23)	Clausewitz (5:23)	Fuller (9:28)	Fuller (8:70)	Foch (7:8)	Maurice (15:27)
Objective	Objective	Objective	Maintenance of the aim or object		Object
Offensive	Offensive	Offensive	Offensive power		Offensive
Concentration	Concentration	Concentration	Concentration of force		Concentration
	Economy of force	Economy of force	Economy of force	Economy of force	Economy of force
Mobility	Mobility	Movement	Mobility of action		Mobility
Coordination		Cooperation			Cooperation
		Security	Security of action	Security	Security
Surprise	Surprise	Surprise	Surprise		Surprise
	Morale				
	Exploitation				
				Freedom of action	
				Free disposal of forces	

Figure 1. Principles of War by Author

United States Air Force	United States Army	Great Britain & Australia	Soviet Union	France	China
Objective	Objective	Selection and maintenance of the aim	Advance and concentration		Selection and maintenance of the aim
Offensive	Offensive	Offensive action	Offensive		Offensive action
Mass	Mass	Concentration of force	Concentration	Concentration of effort	Concentration of force
Economy of force	Economy of force	Economy of force	Economy of force		
Maneuver	Maneuver	Flexibility	Maneuver and initiative		Initiative or flexibility
Unity of command	Unity of command	Cooperation	Combined arms		Coordination
Security	Security	Security	Adequate reserves		Security
Surprise	Surprise	Surprise	Surprise and deception	Surprise	Surprise
Simplicity	Simplicity				
Timing and Tempo					
Logistics					
Cohesion		Maintenance of morale	Morale		Morale
		Administration			
			Annihilation		
				Liberty of action	Freedom of action
					Mobility
					Political mobilization

Figure 2. Principles of War by Nation
(36:Fig 2; 42:2-5 - 2-10; 46:173-177)

1953 & 1954 Principles of War	1955 & 1959 Principles of Employment	1964 & 1971 (See note below)	1975 Employment Principles	1979 Principles of War	1984 Principles of War
Objective	Objective		Objective	Objective	Objective
Offensive	Initiative		Offensive	Offensive	Offensive
Concentration	Concentration		Concentration	Mass	Mass
Economy of effort	(discussed under concentration)		(discussed under concentration)	Economy of force	Economy of force
Flexibility				Maneuver	Maneuver
Control cooperation	Control entity		Unity of effort	Unity of effort	Unity of command
Security	Security		Security	Security	Security
Surprise	Surprise		Surprise	Surprise	Surprise
				Simplicity	Simplicity
				Timing & tempo	Timing & tempo
					Logistics
					Cohesion
			Defense	Defensive	

Note: Principles of war not discussed in 1964 and 1971 editions.

Figure 3. U.S. Air Force Principles of War in AFM 1-2 and 1-1 (50:37; 42:2-5 - 2-10; 43:5-4 - 5-8)

> abstract that they mean different things to different men, and, for any value, depend on the individual's own understanding of war. The longer one continues the search for such omnipotent abstractions, the more do they appear a mirage, neither attainable nor useful--except as an intellectual exercise (14:347).

As has been shown, there is not even a universally agreed upon list of principles of war which should be applied. Of what use are the principles of war then? The opinions of three individuals may be helpful.

USING THE PRINCIPLES OF WAR

Opinions on the proper use of the principles of war fall into three main divisions. Some like Liddell Hart and Weigley see little use for the principles (14:347; 22:214-215). A second generally held opinion is that the principles of war serve only as a means of instruction, a means of developing judgment in the conduct of war, an aid to the study of military history. Clausewitz, speaking of theory in war said, "It is meant to educate the mind of the future commander, or, more accurately, to guide him in his self-education, not to accompany him to the battlefield . . ." (3:141). This view is held by Foch (7:8-21), Maurice (15:47-48), and Preston and Wise (17:3). A final group, Holley (29:--; 30:--; 31:--), Starry (36:--), and Collins (5:--), sees the principles as an operational tool, an aid to judgment for carrying out current operations, while noting they are not prescriptive of specific actions.

Major General Holley, while noting some problems with the principles of war, sees them as an aid to thinking and a final check in the planning process. He notes that principles are abstract (29:92-93). He acknowledges the disagreements between the various lists, and that in some situations different principles seem to contradict each other (28:48). Holley sees the principles of war as really only applying to the tactical level of war, preferring to call them "principles of battle" (28:48). His perspective on the principles of war is that they are,

> . . . not mandates speaking with the authority of a law of nature. Most certainly they do not operate with the inexorable quality of gravity; they are, rather, a convenient checklist. They are prods to thinking, not cookbook ingredients to be spooned in routinely. The justification for having a list of principles is their use in stimulating thought, no more (28:48-49).

Finally, if nothing else, the principle of war can be used as a check on plans after they have been drawn up (28:48). While Holley's emphasis is on the tactical level, Starry sees a broader

application.

For General Starry the principles of war can actively contribute to the development of military plans by providing a framework for the analysis of both strategic and tactical issues. Like others, he does not see the principles acting as immutable laws governing military operations, or in providing specific courses of action for a particular situation (36:3). Specifically, he says,

> Their value lies in their utility as a frame of reference for analysis of strategic and tactical issues. For the strategist, the principles of war provide a set of military planning interrogatives--a set of questions that should be considered if military strategy is to best serve the national interest. For the tactician, these principles have provided an operational framework for the military actions he has been trained to carry out (36:3).

Starry notes that the application of the principles of war to the tactical level is rather commonly perceived. However, he also sees their usefulness in the "military estimate and decision process as an aid to judgment and analysis" (36:12).

Where Holley's use of the principles of war focused at the tactical level, and Starry saw both strategic and tactical implications, Collins addresses the use of the principles at the level of grand strategy. Collins, in Grand Strategy: Principles and Practices (5:--), provides twelve principles specifically for use in grand strategy which consider all the means of national power. Collins, like both Holley and Starry, acknowledges the limitations with the principles of war--they are not universally accepted, they are not immutable, and their application changes with the situation (5:24-28). Despite these problems, Collins feels, "the Principles of War can [italics] be used as a practical checklist to assist sound judgment by the architects and appraisers of strategic theories, concepts, and plans, provided they are administered sensibly" (5:24). Collins ends his discussion of the principles of war with the following conclusion:

> . . . successful strategists never knowingly violate the Principles of War unless they first evaluate the risks and estimate expenses. Readers who apply this yardstick to any conflict or period of international tension in history must conclude that--critics notwithstanding--the Principles of War are [italics] utilitarian and they do [italics] make sense. The record shows that winners, by and large, took heed of the Principles. The losers, discounting those who were overcome by sheer weight of manpower and material, by and large did not (5:28).

Based on the above discussion, the principles of war should apply to space operations, but will not provide specific courses of action. Space as a medium for conflict, the space systems of today, and possible future space weapons all present problems, opportunities, and concepts which are totally new for the development and use of combat power. The country which ignores them, or lacks the imagination to incorporate them in the development of space strategy, does so at great risk to its national security. The principles of war can contribute by stimulating thought about the possible employment of space forces through all levels of the strategy process. Some thought provoking questions would be: what is the object; how can space forces be secured; is there a place for offensive action in space; how can surprise be achieved; what would constitute mass for space operations; and how might space forces exercise maneuver? The next chapter reviews the available literature on how the principles of mass and maneuver are thought to apply to space operations.

Two editions of Air Force Manual 1-1 span the time period during which the included reports were written (43:--; 42:--). The reports in general based their analysis upon the definitions of mass and maneuver contained in the manual which was in effect at the time. As the wording of the principles within each is different, they are provided in the appendix in their entirety.

CONCLUSION

This chapter briefly examined the principles of war and considered how they might aid the development of space doctrine. The principles of war are key precepts derived from a critical analysis of military history. However, rather than a universally agreed upon list, there are numerous different lists reflecting different ways of combining the major concepts into a single set of principles. Further, the lists continue to change. Adding to this complexity is that the principles are interdependent and interrelated making the application of any single principle to a particular situation difficult. Because of the confusion and abstraction of the principles, many have questioned their value. Others see them as useful in only an intellectual sense for help in training the judgment of military leaders, or in studying military history.

However, three individuals, Holley, Starry, and Collins, while recognizing the limitations of the principles of war, provided a more positive use for them. They see the principles of war as thought provoking aids to formulating and evaluating military operations. Taken together, the principles of war provide a framework for the critical analysis of all levels of military operations. Thus far, reports on the application of the principles of war to space operations have come almost entirely from Air Force sources relying upon the definitions of the

principles as contained in two editions of Air Force Manual 1-1, the 1979 and 1984 editions. The definitions of mass and maneuver from each were provided as this report moves into a review of how the principles of mass and maneuver are seen to apply to space operations.

Chapter Three

DO MASS AND MANEUVER APPLY TO SPACE WARFARE?

The principles of mass and maneuver have received only limited acknowledgment in being applicable to space operations. Five reports have directly addressed the application of the principles of war to space operations. Neither the current signed or the latest "for comment" draft of Air Force Manual 1-6, Military Space Doctrine, considers the application of the principles of war (41:--; 54:--). An October, 1985 draft of Air Force Manual 2-XK, United States Air Force Space Operations, which was never published, included an annex on the application of the principles of war to space forces (56:33-37). However, this annex was deleted from the September, 1987, "for comment" draft of the document (55:--).

Paul Siglin in 1970 asserted that both the principle of mass and the principle of movement were applicable to war in outer space (53:4-7). For Siglin, the principle of mass implied the concentration of combat power in on-orbit and reserve, ready to launch spacecraft, mobilized against a specific threat. These spacecraft could be "strategically spaced and controlled ... to provide quantitative and qualitative mass at a desired area of potential conflict or actual confrontation" (53:4-5). Siglin also felt space systems with their tremendous speed and maneuverability provided greatly increased potential for applying the principle of movement to deploy and sustain military forces. He wrote:

> Orbiting vehicles, capable of free flight, can provide a mobile force with immediate response well in advance of present-day concepts. Manned or unmanned vehicles, with controllable power supplies for use to alter the unit into a new desired path, may provide the rapid, economical mobility desired of a military weapon system. Supply and force movements, in the present-day conventional sense, will be provided by space transportation vehicles presently in embryonic development by NASA (53:6).

Charles Friedenstein has argued that neither concentration or maneuver applies to space, due to current system limitations with their lack of maneuvering fuel, high cost and inflexible design (25:--; 50:--). For Friedenstein, concentration implied

the movement of deployed spacecraft to achieve a localized superiority of force. However, the tremendously large fuel requirements for maneuvering prohibit the massing of spacecraft. This implies, "any attack against orbiting spacecraft will probably be a one-on-one engagement against a very predictable target" (25:19). Friedenstein also considered if the support provided to military commanders by space systems could in a sense be concentrated, but concluded that the systems as designed and deployed in peacetime provide all the required capability needed. The only considerations possible were the costly use of on-orbit spares or launch of replacements. The lack of maneuvering fuel also invalidates the principle of maneuver--"If there is anything that space systems do not have, it is maneuverability" (25:19). He also considered satellite reconfiguration under this principle, but still rejected the principle because of the lack of access to orbiting spacecraft and their inflexible design. Reconfiguration of spacecraft is really only done to activate redundant systems in response to anomalies (50:45).

Chalton Watters wrote on maneuver as a characteristic, and concentration as a capability of aerospace forces as provided by AFM 1-1. He rejected both as applying to orbiting spacecraft in the same way they apply to aircraft. His reasoning for rejecting maneuver was that spacecraft outside the atmosphere have no means to generate aerodynamic forces to change their velocity. Instead, they must rely on on-board fuel for any maneuvers. With normal fuel supplies this allows only minor, slowly obtained changes in altitude. However, the lack of aerodynamic forces also means that spacecraft can be pointed in any direction, using little fuel, without affecting the flight path. As a result, spacecraft really possess pointability instead of maneuverability (57:21-24). He rejected concentration since it is based partly on maneuver, and in consideration of the tremendous volume of space (57:27). However, Watters noted that the consideration of directed energy allows a different notion of concentration to apply to spacecraft. Directed energy beams without mass are not constrained by orbital mechanics. Also, the vacuum of space allows directed energy beams to travel essentially without attenuation over great distances (57:25-26). Concentration can again be achieved by combining spacecraft pointability with these characteristics of directed energy in the following manner:

> Concentration ... can be regained ... in the form of satellites carrying directed energy weapons, orbiting several thousand miles up. From that height they would each have line-of-sight coverage of much of the low earth orbit region. By rotating and firing their weapons individually or in groups, the satellites could concentrate firepower anywhere in low earth orbit (57:31).

The concepts of pointability and the concentration of directed energy by dispersed satellites have been retained by subsequent

reports on space doctrine.

One such report, "Military Space Doctrine for the Twenty-First Century," poses an environmental space doctrine model which retains the principle of mass and indirectly the principle of maneuver (51:--). While the principle of mass is retained, it is not applied in its traditional sense of co-locating forces at the decisive point and time. Instead, like Watters, the report indicates that firepower can be concentrated using directed energy weapons from vastly separated spacecraft (51:32, Appendix 2-4). The report addresses maneuver in two ways. First as a doctrinal implication of the space environment, the report agrees with Lupton that space forces are "quasi-positional" in that while they are constantly moving, their future positions can be accurately predicted using orbital mechanics unless maneuvered. However, maneuverability of orbiting spacecraft is severely restricted due to lack of sufficient on-board fuel (31:37-38 and 51:30). Small maneuvers are possible for pointing weapons and sensors (pointability), and making slight orbital changes "forcing incoming weapons to adjust their guidance and thus expend energy in changing course" (51:29). The second way the report covers the principle of maneuver is indirect in that maneuver is combined with the concepts of flexible response and mobility to become "freedom of action/flexible response" (51:21). This new element is defined as follows:

> This principle may be thought of in physical terms as systems possessing sufficient degrees of freedom in motion and sufficiently diverse types of weapons systems to respond in location and kind to enemy threats. Its purpose is to place the enemy in a position of disadvantage by movemert or concentration of forces ([1]:14). Fluidity on the field of battle allows concentration of forces against known weak points and the rapid response against attack (51:21).

Specific application of freedom of action/flexible response indicated maneuverability of spacecraft was available in pointability and altitude, but extremely limited in changing the orbital plane. Additionally, slight change to the orbital period of a spacecraft can result in sufficient movement from its predicted position to make targeting difficult. Gravitational attraction for acceleration and atmospheric skip for deceleration are additional methods for maneuverability in addition to on-board fuel (51:33). Finally, the report noted, "the flexibility available from a combination of manned or unmanned assets, intelligence systems, and various weapons allows tailored response to any threat" (51:33).

The last report which covered the principles of mass and maneuver applied to space operations is "A New Environmental Military Space Doctrine: For Today and Tomorrow" by Crotty,

Hensz, Meyer, Miatech, and Reid (49:--). The report concludes that mass does not apply and needs to be changed to concentration of force, while maneuver does apply with the subprinciples of deployability and pointability. The tremendous volume of space and the requirements of orbital mechanics excessively constrain the ability to concentrate forces in the traditional application of mass. Like Watters, however, this report concludes that the same effect of mass can be accomplished by widely separated spacecraft by focusing their firepower on selected targets. Going beyond Watters, the report applies this concentration of force to force enhancement spacecraft assisting land, sea and air forces to more effectively mass their combat power (49:78-79, 101-102). While the principle of mass was rejected, the principle of maneuver was accepted, and even expanded. Crotty and the others advocated that maneuver is "as important a principle for space operations as it is for the other three environments [of land, sea, and air]" (49:85). Currently, maneuverability of spacecraft is constrained due to a lack of advanced propulsion systems. Once this temporary technological constraint is removed, maneuver will only become more important. Even under the current contraints, maneuver is extremely important as demonstrated by one of the last shuttle missions where maneuver was used to retrieve two disabled satellites, and current anti-satellite systems which use terminal guidance and maneuver to complete their attack (49:84). Two subprinciples of maneuver were also seen as important--deployability and pointability. Deployability was defined as "the ability to move space forces from earth or deep space so as to rapidly and successfully engage an enemy" (49:102-103). Pointability was defined the same as Watters, but included the idea of rapidly pointing and firing directed energy weapons from target to target, which, like the weapons themselves, may be greatly separated. (49:86).

Taken together these documents represent an evolutionary development of how the principles of mass and maneuver could be applied to space forces. However, they also represent only the opinions of the individual authors. In order to be considered doctrine, their opinions would have to receive a general endorsement by the military services. One indication of general acceptance would be incorporation of the ideas into AFM 1-6, Military Space Doctrine (41:--; 54:--), and AFM 2-XK, Operational Doctrine for Space Operations (56:--; 55:--).

Current official documents pertaining to space operations do not discuss the principles of war or how the principles might be applied to space operations. The current AFM 1-6 is dated 15 October 1982, which was too early for the above reports to be considered (41:--). It contains no reference to the principles of war. A "for comment draft" of a new AFM 1-6, dated 15 September 1987, has been distributed for review by the Air Staff and the major commands. Noting the great amount of energy required for even small plane changes, it notes "constrained

maneuverability" as a characteristic of space forces (54:6, 8). It also contains no reference to the principles of war. AFM 2-XK, Operational Doctrine for Space Operations has never been published by the United States Air Force. An unofficial draft, dated 9 Oct 1985, reviews the principles of war in Annex 3 (56:33-37).

The October 1985 unofficial draft of AFM 2-XK incorporated both the concentration of force and maneuver in applying the principles of war (56:--). Both principles seem to incorporate the evolution in the reports above, perhaps even quoting directly from them. At best the draft can only be considered the temporary opinion of the action officer involved. Both principles are quoted in full as follows:

> Concentration of Force.
>
> a. Concentration of force entails the focusing of firepower by space forces against selected targets. It also includes the focusing of all types of force enhancement as support for land, sea, and air forces. This support includes data collection, surveillance, early warning, navigation, communications, weather, or any other type of support.
>
> b. A unique aspect of space allows massing of force at the appropriate time without the collocation of assets, i.e., energy can be focused from vastly separated sources to a single point for force application or data transmission. Therefore, space fleets composed of complementary assets may be assembled without the associated hazard of massing expensive and vulnerable assets. Such "long-distance" support can help protect civilian assets in space.
>
> c. By judicial application of the principle of concentration, a widely separated space force which is inferior in strict numbers, may defeat a superior force, or may support the defeat of the superior force by terrestrial forces (56:34).
>
> Maneuver. The ability to maneuver involves repositioning space forces. Because of weight and cost penalties associated with large on-board maneuver capabilities, as well as the basic laws of orbital mechanics, orbit change maneuvers are presently generally quite limited. However, the ability to outmaneuver a potential enemy, to change earth coverage patterns, or to deploy space forces are [is] easily achieveable [sic]. Maneuver provides the flexibility necessary for effective space operations. It includes physical movement from one location to another, plus deployability and orientation. Deployability is the

> ability to move space forces from earth to space so as to rapidly and successfully engage an enemy. Orientation is the ability to alter the payload of a spacecraft to allow it to bring its weapons or data collection or transmission device to bear upon the desired target while the vehicle remains on its original flight path (56:35).

This draft of AFM 2-XK was never published. A "for comment draft" of a new AFM 2-XK, dated 10 June 1987, has been distributed for Air Staff and major command review (55:--).

The June 1987 draft of AFM 2-XK does not address the principles of war (55:--). It does list four "principles of employment," which also happen to be principles of war listed in AFM 1-1, assuming that the principle of offense can also be called initiative. The four principles of employment listed are unity of command, security of forces, initiative, and economy of force (55:3-3 - 3-4). Since neither the current AFM 1-6, the new draft AFM 1-6, nor the draft AFM 2-XK includes the principles of war, there is no current official Air Force position on the particular application of the principles of mass and maneuver to space operations, nor is there likely to be an official position in the near future. This in turn implies that the principles of war in AFM 1-1 will apply to space operations as written, despite the problems and lack of insight which they hold for space operations.

Analysis of the writings to date on the application of the principles of mass and maneuver to space operations indicates three major limiting conceptual deficiencies. First, too narrow a definition of the principles of mass and maneuver was used. All used the definitions contained in the edition of AFM 1-1 which was current at the time. In the 1979 version, mass required the concentration of forces at a specific location, but was changed in the 1984 version to the concentration of firepower (43:5-5; 42:2-7). Maneuver, in both editions, requires the movement of forces in relation to an enemy's movement of forces. The next chapter will show that much more is implied under the principles of mass and maneuver than mere collocation of forces and movement of forces.

Secondly, the concepts were applied almost uniformly only to orbiting spacecraft and spacecraft in some reserve capacity (ready for launch, or in deep orbit). Firepower was limited to on-orbit use of directed energy weapons. The principles should have been applied to a full space force working together, with each system made up of segments, only one of which is the space segment. Further, all the functional areas in which space forces contribute to combat power should be considered, as well as the use of other forces against the space forces. Chapter five provides a fully integrated approach to the use of space forces which, if used, will overcome this problem area.

The third limiting deficiency is that all implicitly applied too narrow a definition of the relevant theater of war for space operations. The theater for operations conducted in space was the volume which included current satellite orbits out to geosynchronous altitude. The theater for space support of terrestrial systems was confined to a theater in today's sense, such as Southeast Asia, the Middle East, or Northern Europe. The exception is Crotty's use of deployability from deep space, but it was used only in considering maneuver. The space theater of war is, at the very least, global in nature. Stine (19:Chapters 5 and 6), and Vaucher (21:--) have already fully defined the space theater of war which should be used in considering mass and maneuver.

Chapter Four

THE PRINCIPLES OF MASS AND MANEUVER

INTRODUCTION

The opinions on the applicability of mass to space operations reviewed in the last chapter were based upon the view that the application of mass required the collocation of assets. Satellites, as currently built and deployed, do not have sufficient on-board maneuvering fuel to collocate the space force. Thus the traditional use of mass was not seen to apply, shifting primarily to the concentration of effort. Under this idea was seen a way to concentrate the fire of widely dispersed space vehicles. This represents an extremely limited application of the principle of mass.

Likewise, the opinions on the applicability of maneuver to space operations were based upon the view that maneuver is based upon the physical change in the velocity of a spacecraft. Maneuver applied to the launch of a spacecraft, rotation of a spacecraft to change its orientation, or a change to the orbit of a satellite. Because of the large fuel requirements for significant changes in a spacecraft's orbit, satellites are viewed as quasi-positional, and thus maneuver was seen to apply only in a very constrained manner. Instead, launching of satellites was incorporated as deployability, and the changing of a satellite's orientation led to pointability. As with mass, this represents a very limited application of the principle of maneuver.

The principles of mass and maneuver are far more substantial than applied thus far to space operations. So far only the tactical context of the principles has been addressed, yet as principles of war they should apply equally to the strategic and operational levels. Further, a wide survey of both principles indicates far more is involved than collocation and movement of forces. Twelve sources were examined to establish the key concepts which make up the principles of mass and maneuver. These twelve sources included the following: Sun Tzu (20:--), Napolean (16:--), Jomini (13:--), Clausewitz (2:--; 3:--), Foch (7:--), Fuller (9:--), Maurice (15:--), Liddell Hart (14:--), Collins (5:--), Savkin (18:--), the United States Army's Field Manual No. 100-5 (FM 100-5) (46:--), and the United States Air

Force's Air Force Manual 1-1 (AFM 1-1) (42:--; 43:--). A problem occurred in that all the sources discussed mass and especially maneuver differently. There was so much differing material with just the hint of several underlying themes, that a consistent, logical, and efficient application of these principles could not be made directly to space operations. A more universal definition of both principles had to be derived.

A broad organization of what constitutes the principles of mass and maneuver emerged using the twelve sources mentioned above, along with considerable thought, generalization from the historical context, and inclusion of concepts which some authors dealt with under different topics. The sources used provided a relative convergence into five concepts which together make up mass. The principle of maneuver appears more historically bound in thought and thus did not converge as readily as mass. However, there appear to be five concepts which constitute maneuver. This chapter is divided into two major sections which first provide a detailed inclusive definition of mass and then maneuver.

MASS--THE MEANS TO VICTORY

This section includes a basic definition of mass, the overall importance of mass, its application to all levels of warfare, its relation to several of the other principles of war, and five detailed concepts which more fully describe mass. First this section presents a basic definition of mass with a comparison of how the various sources include the principle of mass. Secondly this section will show that the attainment of mass is thought by many to be the most fundamental precept in war, and applicable to all levels of warfare. Then to help understand the principle of mass, its linkage to the principles of economy of force, security, maneuver, and surprise is examined. Next, the five concepts which are embodied within the principle of mass are explained. These concepts involve the importance of thorough, accurate planning, the correct selection of the decisive point and time, the simultaneous strategic use of all available forces, the correct distribution and maneuver of forces for their employment, and the relentless, courageous pursuance of the attack against the decisive point.

The essence of mass is the concentration of destructive combat power at the decisive point in space and time so as to achieve decisive results. Sun Tzu (20:--), Napolean (16:--), Jomini (13:--), Clausewitz (2:--; 3:--), and Liddell Hart (14:--) really did not define a list of principles in the modern sense. Jomini and Liddell Hart defined a single fundamental principle of war based upon mass which was then further defined in four and eight maxims respectively (13:63; 14:347-349). Clausewitz's "first principle of strategy" is essentially the modern definition of mass given above (3:195). Foch combines the the

principles of objective, offensive, mass, economy of force, and surprise into a single principle--economy of force (7:44-47). The above definition of mass fits only a small part of Fuller's definition of the principle of concentration (9:33-35). However Fuller's definition of concentration is not replicated by other sources. Maurice's and Collins' principle of concentration fits this definition (15:215, 238; 5:26). Savkin's principle which is equivalent to mass is the following: "Concentration of Main Efforts and Creation of the Necessary Superiority in Men and Weapons Over the Enemy at the Decisive Place at the Decisive Time (Concentration of Efforts)" (18:201). Both the United States Army and Air Force define the principle of mass basically as given above (46:174, 42:2-7). Mass as a principle of war, while used under different names, has been widely recognized. In addition to its wide acknowledgment, mass is considered by many to be the key to understanding war.

Five of the sources indicated that mass is the most fundamental principle of warfare. Clausewitz regarded mass as, "fundamental--to be achieved in every case and to the fullest extent possible extent" (3:197). Jomini said that mass was the "one great principle underlying all the operations of war,--a principle which must be followed in all good combinations" (13:63). Liddell Hart considered "concentration" to be the distilled essence of the principles of war (14:347). Maurice also felt that all the other principles of war culminated in the principle of concentration (15:215). Savkin indicated concentration of efforts has been the most decisive factor in warfare (18:201). Mass is thus vital to an understanding of war. Understanding mass and how it might apply to military space operations appears absolutely essential for the successful conduct of space warfare.

While classically mass has best been understood in its application to the tactical level, the sources used clearly show that it applies to all levels of war with one of the key differences being the definition of the decisive point. One of the causes, and benefits, in the variations among how the sources treated mass was the emphasis on different levels of warfare. For instance, Collins' work was focused at the level of grand strategy (5:24), Savkin's at the operational level (18:--), Foch's at the tactical (7:--). The United States Army's description of mass was broken into separate descriptions of application to the strategic level, and then to the operational and tactical levels (46:174). Perhaps the key to understanding the application of mass to the different levels of war is understanding what the decisive point is at the different levels. At the strategic level FM 100-5 uses, "regions or areas of the world where the threat to vital security interests is greatest" as the decisive point, at the operational and tactical levels it uses "decisive place" (46:174). For the operational level Savkin uses "decisive place," "axis of main attack," "decisive axis," and "chosen sector," in addition to "decisive point"

(18:201-229). The use of these different terms allows an easier application of the principle to the strategic and operational levels. The decisive point simply gets bigger as you go up in level. The concept behind the principle for the allocation of forces remains unchanged. Full understanding of this principle requires not only realizing its application to all levels of operations, but also how it works with several of the other principles of war.

The principle of mass is especially linked to the principles of economy of force, security, maneuver, and surprise. Economy of force implies two different precepts in the employment of forces, and is so integral to understanding mass that in three instances the two principles are combined. The first implication in economy of force is that no more force than required be employed to obtain an objective. This definition was the only one used in the 1979 edition of AFM 1-1 (43:5-5). More traditionally, economy of force implies that the fewest possible resources be used in secondary efforts to allow for the greatest possible force at the decisive point (mass) (7:Chapter III; 15:Chapter VI; 9:35-36). Secondary efforts are used to locate, fix, probe, and deceive an enemy force (7:48). Secondary efforts facilitate concentration at the decisive point, but decrease the actual forces available at the decisive point at the decisive moment (15:109-111; 14:342). To Savkin mass and economy are so related that there is no need for economy of force to be a separate principle of war (18:201). Foch's principle of economy of force certainly includes mass (7:48; 15:106-107). The United States Air Force in the current AFM 1-1 discusses mass and economy of force together (42:2-7).

Economy of force, and thus mass, are especially tied also the principle of security. Through security, a concentration of force is protected from attack. Security is a secondary effort to which the least force possible must be devoted (7:46). Maurice considered security to be the "foundation" upon which all operations were carried out (15:215).

Likewise, both maneuver and surprise are closely associated with mass. Maneuver provides the means to concentrate and disperse a force. Further, maneuver gives movement of the concentrated force for the attack to create shock (7:45). Without surprise mass is not possible. Clausewitz said about surprise that ". . . without it superiority at the decisive point is hardly conceivable" (3:198). With this background the principle of mass can be explained further as consisting of five major concepts.

There are several ingredients which must be combined to obtain mass, the first being the need for thorough, accurate planning. At the strategic level, the United States Army calls for the preparation of "suitable contingency plans" (46:174). Foch's economy of force involves preparation as one of three main

factors. He says the following about preparation:

> . . . there must be in your mind a plan of action, based on a thorough study of the task or mission assigned, as well as on a detailed, minute examination of the ground; a plan liable, of course, to alteration. You must have troops disposed and drawn up as to be able to prepare and undertake the execution of that plan; so that you may be able , so to speak, to express it: advance guards and flank guards in particular (7:47).

Clausewitz says simply that mass is based upon ". . . suitable planning from the start" (3:197). The fruit of this planning is the correct selection of the decisive point which in turn leads to the proper employment of one's forces, and the confidence to resolutely pursue your plan in the face of many risks (3:197).

The correct selection of the decisive region, axis, and point is the second concept of mass, but for all their importance very few have attempted to define them. Only three works have offered a definition. In a strategic context, the United States Army defines the critical region as the one which has the greatest threat to vital national interests (46:174). At the operational level, Savkin indicates the decisive axis or point is ". . . a key position or that grouping of enemy troops, the defeat of which would lead to his loss of stability in the defense" (18:229). Jomini, however, deals with the subject at length. To summarize, Jomini breaks the decisive points of a theater into decisive geographic points and decisive points of maneuver. Decisive geographic points are based upon the physical features of a country and as such are of lasting importance. They include centers of communication, capitals, and mountainous defiles. Decisive points of maneuver are based upon the enemy's disposition and are those points which cut the enemy force from its base and supporting forces (13:78-79). Finally, at the tactical level, Jomini states:

> The decisive point of a battlefield will be determined by,--
> 1. The features of the ground.
> 2. The relation of the local features to the ultimate strategic aim.
> 3. The positions occupied by the respective forces (13:80).

The decisive point, once determined, governs the employment of force in space and time.

However, no discussion of what determines the right time was found. The key concept with regard to time, coming from Clausewitz, is the unification of forces in time. Under this concept Clausewitz allows for the successive employment of forces

at the tactical level, but at the strategic level, all of one's forces should be used simultaneously. Clausewitz suggested the following rule: "all forces intended and available for a strategic purpose should be applied simultaneously; their employment will be the more effective the more everything can be concentrated [in] a single action at a single moment" (3:209).

Unification of force in space and time is achieved through the dispositions of a force, which is a balance between their concentration and dispersion based upon several factors. The important points seem to be to create a dispersal of the enemy by dispersing, or appearing to disperse, one's own force at the same time protecting them from a concentrated attack. Once the enemy dispersion is obtained, there is the concentration of one's force against the enemy's weakness before his reactive concentration can occur. This sequence of events underscores the importance of maneuver to mass (18:225; 15:216-218; 14:347). As Liddell Hart put it, "True concentration is the fruit of calculated dispersion " (14:347). The factors affecting such calculations should include the geography of the theater of operations, means of communication, available mobility, logistical support, the numbers of troops, and their weapons. In fact the lethality and range of modern weapons have significantly altered the traditional concept of concentration.

With today's weapons, especially nuclear weapons, forces are dispersed over wider areas, and the fire of long range weapons can be concentrated against enemy positions. During the Napoleonic wars the ground force dispersion was 200 square meters/man. Due to the increased lethality during World War II, this dispersion increased to 27,000 square miles/man. In the 1973 Arab-Israeli War, the ground force dispersion was 40,000 square miles/man (6:312). If nuclear weapons are added, this dispersion can be expected to increase still further. Savkin views the impact of nuclear weapons of such importance that the principle of mass becomes the concentration of effort. He states, "The concentration of large masses of troops in small areas in nuclear warfare has become inadmissible for considerations of security, since in so doing the troops might suffer immeasurable losses . . ." (18:282). Further, however, he doesn't see a need for such concentrations today. Savkin has advocated the concentration of long range nuclear missile strikes against enemy forces on the chosen axis (18:282). Liddell Hart also rejects the traditional idea of an attack by a concentrated force. Instead, he advocates, ". . . that advancing forces should not only be distributed as widely as is compatible with combined action, but be dispersed as much as is compatible with cohesion" (14:346). The principle of mass no longer requires the collocation of forces. Instead, the destructiveness of their combat power is concentrated. Besides the concept of a balance between dispersion and concentration in modern combat, there remains one further aspect of force employment which must be examined.

The last concept which makes up the principle of mass is the relentless, courageous pursuance of the attack upon the decisive point. Merely attaining a superior concentration of personnel and weapons is insufficient. A superiority of morale is also required. The commander must have the courage to place a portion of his force at disadvantage in order to produce the concentration where required, and the resolve to maintain the concentrated attack when secondary actions or lesser points appear in jeopardy. The force concentrated must attack with great spirit, ruthlessly and relentlessly sweeping aside all enemy opposition. As Jomini put it, the force concentrated must "engage . . . with energy" (13:63). Foch used the term "impulsion" to describe the concept (7:44-47). Savkin quoting Suvorov uses the following: "Visual estimate, swiftness, and onslaught" (18:229). From Sun Tzu there is, "Thus the momentum of one skilled in war is overwhelming, and his attack precisely regulated" (20:92). Clausewitz provides a most insightful description of this factor which is essential to mass as follows:

> . . . the correct appraisal of the opposing generals . . ., willingness to risk facing them for a time with inferior forces, energy for rapid movement, boldness for quick attacks, and the increased activity which danger generates in great men (3:196-197).

Summarizing shortly after this, Clausewitz said that mass depends, among other things, on, ". . . the resolution needed to sacrifice nonessentials for the sake of essentials--that is, the courage to retain the major part of one's forces united" (3:197). Taken together this fifth concept provides the psychological element which is part of the principle of mass.

There are then five concepts which together make up mass, including not only a consideration of the physical forces involved, but the psychological element as well. Mass consists not of just the collocation of troops for superiority, but the concentration of destructive combat power at the decisive point in space and time. This in turn depends upon superior planning, the correct selection of the decisive point, the simultaneous strategic employment of all available forces, the balanced disposition of forces between dispersion and concentration to create the necessary vulnerability and then exploit it, and finally, the resolute execution of the plan with great spirit. One of the chief means to create mass lies in the principle of maneuver.

MANEUVER--THE CAPABILITY TO ADAPT

The principle of maneuver was examined in the same manner as mass. This section presents the results of that review and includes a discussion of the problems encountered in reviewing

maneuver, and then a detailed explanation of the five concepts which taken together comprise maneuver. The principle of maneuver was difficult to examine and summarize because of the lack of consensus on the principle.

The principle of maneuver, while it has a firm basis in the military classics and is widely acknowledged today, remains a very elusive concept under comparative research. A common central definition beyond the movement of forces to achieve mass is not found. Neither is a common terminology found. So what has happened, and can the differences be resolved?

The lack of a consistent content and terminology for maneuver can be found in two broad areas involving the evolution of technology and an inconsistent definition of the principles of war. Past authors have been particularly constrained by the technology of their time. The evolution of technology has increased tremendously the mobility of military forces; the means of command, control, and communications; and the destructiveness and range of weaponry. The result has been larger and larger military forces capable of ever faster transport over ever longer distances, with ever increasing firepower. Military theory has had to adapt to this ever increasing mobility, control capability, force structure, and weaponry. The result has been a continuously increasing complexity to which the principle of maneuver has applied. Thus has a different terminology been involved, and the concepts within maneuver been expanded. Compounding this problem has been the formulation of different lists of principles under the various concepts are grouped. Thus one author's principle of economy of force (7:Chapter 3) may include another's principle of mass, maneuver, economy of force, and timing and tempo (42:2-7 - 2-8). The problem then is how to reconcile these differences to arrive at a full concept of maneuver meaningful for today.

Resolution of the problems with maneuver requires a generalization of the concepts used by various writers, and the inclusion of some concepts addressed by some authors outside the principle of maneuver. Generalization is required because past theorists wrote to explain the use of the military forces of their day. Much of military skill involves understanding the capability of current forces and their employment. Generalization helps to remove the technological limitations under which the theorists were constrained. For instance, Jomini's decision in maneuver was limited to three choices, "...to the right, to the left, or directly to the front..." implies a concept which really does not mean much for space warfare (13:64). However, knowing what options for maneuver are possible with space systems, his advice that, "...executive talent, skill, energy, and a quick apprehension of events are necessary" may be useful for comparison with others for what makes for success in maneuver (13:64).

Inclusion of concepts outside maneuver by some authors is required to obtain a more complete comparison. For instance, Maurice uses quickness of decision as a factor contributing to his principle of mobility (15:177). Clausewitz also addresses the quickness of decision by a commander, but as part of military genius and not under maneuver (3:102). Savkin discusses the single Soviet principle of mobility and high tempos of combat operations, as applied to operational art and tactics (18:167-201). However, the current Air Force Manual 1-1 defines the principle of maneuver, and then defines the principle of timing and tempo (42:2-7 - 2-8). To provide an equal basis for comparison, concepts within the Air Force's principle of timing and tempo would have to be considered. Part of the problem then is to decide what concepts actually belong under maneuver. Where a concept was used by several authors, it was considered part of maneuver. Once a concept was considered part of maneuver, if other authors addressed the same concept elsewhere than maneuver, their contributions to the concept were included. Using the first example above, since several authors discuss rapid reaction to changing circumstances involving decisions by the commander under their principle of maneuver, it is included. Therefore, both Maurice's and Clausewitz's comments pertaining to rapid decision were considered.

After a review of the same twelve sources previously listed, a very simple definition of maneuver emerged which includes five general concepts. Maneuver is the adaptable commitment of national power resources at all levels of warfare against a responsive enemy in order to gain an ever more advantageous position. The five general concepts which together seem to constitute the principle of maneuver are maneuver to obtain mass; create and use a mobile reserve; seek the highest possible level of mobility; minimize the observation, decision, and implementation cycle time; and maintain flexibility of thought, plans, and operations. Each of these five concepts is explained in detail below.

Maneuver to Obtain Mass

Maneuver, applying to all levels of war, is the means by which mass is obtained. Collins (5:--), Jomini (13:--), and the United States Army (46:--) describe the concept of maneuvering for mass at the strategic level. Collins indicates that at the strategic level maneuver entails "rapidly shifting strategic emphasis from one mode to another" in the employment of the political, economic, psychological, and military instruments of national power (5:26). The aim of such shifting is to "apportion crushing power at decisive times and places" (5:26). Jomini included strategic maneuver of the army against a theater's decisive points and lines of communications as the first maxim under his fundamental principle of war. The second maxim was to maneuver to achieve mass against portions of an enemy's force (13:63). The United States Army calls this concept

maneuverability, which at the strategic level involves the maneuver of forces within a theater of operations to achieve mass (46:175). At the grand strategy level, maneuver involves shifting between the various instruments of national power in overcoming a foe. In the strategic employment of military forces, the object of maneuver is to bring a mass of force against the decisive points within the theater.

At the operational and tactical levels of warfare, maneuver is still the means to obtain mass, but through the planned concentration and dispersion of forces. Four authors support this as a factor of maneuver. Sun Tzu in his chapter on maneuver instructs, "Move when it is advantageous and create changes in the situation by dispersal and concentration of forces" (20:106). Maurice in his principle of mobility defines maneuver as the "means of engaging in battle to advantage" (15:168). Continuing, Maurice discusses the need for balance between division and concentration. However, his emphasis is on the maxim "divide to march, concentrate to fight" as a means to move an army in a number of columns (15:177). The United /States Army instructs the following for the operational and tactical levels: "The object of maneuver is to concentrate or disperse forces in a manner designed to place the enemy at a disadvantage" (46:175). Savkin writing at the operational level of war sees the rapid concentration and dispersal of forces as being more important than ever in this age with the possible use of nuclear weapons. Maneuver is used to rapidly achieve both concentration on the decisive axis, and dispersal of troops in protection against nuclear attack (18:170). The first precept of the principle of maneuver clearly indicates the injunction to use maneuver to obtain mass. Militarily at the strategic level this involves commitment of units to and within a theater of operations. At the operational and tactical levels, maneuver involves the concentration and dispersal of forces for mass. Very closely tied to this concept is formation and use of a reserve force to deal with the unexpected and to create shock.

Create and Use a Reserve

Based upon the works of Fuller (9:--) and especially Foch (7:--), the principle of maneuver includes the concept of creating and using a reserve force to deal with the unexpected and more importantly to create shock. Clausewitz (3:--) and Jomini (13:--) also both discuss the formation and use of reserves. Fuller sees maneuver as "endowing mass with momentum" (9:36). Further he sees the use of reserves as critical to maintaining the "impulse" of attacking forces (9:37). Foch considered shock, the psychological crushing of the enemy, consisting of mass and impulsion. Impulsion was the energetic commitment of the concentrated forces to battle (7:44-47). For Foch, the decision in battle is gained only by the decisive attack (7:Chapter X). The decisive attack is the result of maneuvering the largest possible reserve in order to hurl it

against the decisive point (7:299-300). Jomini's reasoning for creation of use of a strategic reserve was to protect his line of operations and reinforce threatened positions without affecting the active army (13:120-123). Clausewitz notes the value of a reserve as follows: "It is only with troops left at our disposal that we can turn the tide of battle" (2:319). Clausewitz highlights the especially important point that all strategic reserves should be committed once the decisive state of the battle is reached (3:211). The reserve would be committed to action through the physical movement of the force, which is covered next.

Seek the Highest Possible Level of Mobility

The third concept within the principle of maneuver is that a nation's military force should seek to achieve the highest possible level of mobility. Mobility is the capacity for physical movement of the force and is based upon five factors developed from Maurice (15:Chapter IX). The first factor is the organization of the force for rapid movement, especially the logistical system. Second is the capability of the commander and his staff to plan and direct the movement of forces for employment and sustainment. Equipping the force with the necessary transport is the third factor. At the strategic level, this involves the means to transport the necessary force to the proper theater through strategic airlift, sealift (46:175), and ground transportation. At the operational level, the forces need the capability to shift from one axis or sector to another (18:170). At both the operational and tactical level this would involve theater airlift and the use of armored fighting vehicles. In order to attain and maintain high tempos of mobility, the troops must be properly trained and physically fit--the fourth factor. The final factor is the creation and use of an especially mobile force. An example of this type of unit today would be the airborne infantry division. Mobility as characterized by these five factors provides the means by which the forces are concentrated and dispersed. However, all of this occurs against an enemy, with both sides attempting to achieve the same ends and reacting to the changes perceived. It is for this reason the next two concepts are part of maneuver.

Minimize the Observation, Decision, Implementation Cycle Time

The fourth concept of maneuver involves an armed force's speed of reaction, its observation, decision, and implementation cycle time which must be minimized. This concept has developed intellectually over the course of history being expressed by Sun Tzu (20:--), Clausewitz (3:--), Maurice (15:--), Savkin (18:--), and finally Boyd (34:--). Sun Tzu recognized the need to discern the enemy's dispositions and swiftly maneuver his forces to advantage (20:98-101, 134). The concept during Clausewitz's time was embodied in the coup d'oeil of the commander, which is the ability to take in the military situation, and then make rapid,

accurate decisions under pressure (3:102). Maurice noted that an important element of mobility was the commander's ability for rapid decision making, his highly trained judgment, and the timeliness of the information he receives (15:177-178). Savkin notes several attributes of mobility along this concept which include the following:

> "maneuver and reaction to any change in the situation, even the most abrupt one; . . . the capability to quickly identify targets for delivering strikes against the enemy; . . . and the ability to operate at the necessary moment and at the necessary place faster than the enemy, and unexpectedly for him" (18:168-169).

Savkin later notes the importance of troop control to achieve mobility as,

> the ability of commanders and staffs to comprehend a complex situation quickly and deeply, make the most advisable decision without delay, bring it to the attention of subordinates in the shortest time, and continuously and firmly direct the actions of troops in the interests of successful accomplishment of the combat mission (18:185).

This detection of a change, decision, and execution of the resulting plan are very similar to concepts within Boyd's "fast transient theory" (34:89).

While Boyd's "asymmetric fast transient" theory has not been incorporated into the principle of maneuver, his theory probably represents the latest, fullest development of the speed of reaction concept. Boyd's theory views warfare as a series of observations--orientation-decision--action cycles (Boyd cycles). The side which is able to operate faster or inside the other's cycle is able to gain the initiative and successively degrade the enemy's capability to react (34:89). As Simpson has shown, the Boyd cycle is applicable to all levels of operation (34:91). Part of the capability for rapid reaction would involve the physical means of mobility, examined under the third concept of maneuver, for the quickness in executing military operations (34:90).

There appear to be several other ways of decreasing the Boyd cycle. The time for detecting a change in the situation could be lowered by organizing and equipping a force to seek out changes as quickly as possible and funnel the collected data into an operations center for immediate use and analysis. Once a change is detected, the effect on current operations must be determined and options developed for reaction if not previously planned for. To decrease the time here, a complete understanding of the current situation and operation is required. The creativity of option development will aid the formulation of unexpected actions. Decision analysis and other methods of operations

research can aid in the efficient evaluation of alternatives. Once the decision is made, appropriate changes to the current operation must be finalized and transmitted to the force for implementation. If, however, the current thought, plans, and operations are inflexible, this whole process is complicated and delayed, which brings up the final concept making up maneuver.

Flexibility of Thought, Plans, and Operations

The fifth building block of the principle of maneuver is the flexibility of thought, plans, and operations. Without flexibility in these three areas, a force becomes unable to react as quickly to changes, if at all. The United States Army's definition of maneuver states, "At all levels, successful application of this principle requires not only fire and movement, but also flexibility of thought, plans, and operations" (46:175). Savkin saw flexibility in the thought of commanders as an attribute of mobility (18:168). Liddell Hart noted the following: "To be practical, any plan must take account of the enemy's power to frustrate it; the best chance of overcoming such obstruction is to have a plan that can be varied to fit the circumstances met" (14:343-344). Liddell Hart further highlighted the importance of flexibility in plans and operations in two of his eight maxims of war. His fifth maxim recommended operations which threatened multiple objectives. His sixth maxim called for flexible plans and dispositions (14:348-349). Flexibility is so important that Great Britain and Australia use the principle of flexibility instead of maneuver (36:Fig 2). Collins breaks flexibility out as a separate principle of war while also having the principle of maneuver (5:25). Fuller discusses flexibility of thought,, particularly in regards to doctrine, but under the principle of concentration (9:33-34). Thus flexibility as a concept under the principle of maneuver is perhaps open to some question. None-the-less, flexibility at all levels in thought, plans, and operations appears vital for success in war, and appears to be best considered as part of maneuver.

SUMMARY

This chapter has presented a detailed examination of the principles of mass and maneuver. Both principles were far more substantial that the applications made thus far to space operations. A major problem, particularly with maneuver, was the lack of a consistant definition and terminology. Both principles converged into five concepts each.

Mass was considered by many to be the most fundamental principle in war, and is closely related to the priniples of economy of force, security, maneuver, and surprise. Militarily, mass is the concentration of destructive combat power at the decisive point and time. Strategically, the decisive point

refers to the region where the threat against a nation's vital interests is greatest. Operationally, the decisive point refers to the decisive axis or sector of the theater. Decisive points come about from the geography of the theater, the overall strategic aim, and the dispositions of the enemy force. The means to attain mass were explained under the following five concepts:

1. Thoroughly and accurately plan the operation.
2. Correctly select the decisive region, axis, and point.
3. Strategically use all available forces simultaneously.
4. Distribute the force according to its various capabilities and the threat to bring a superiority of combat power to the decisive point.
5. Relentlessly and courageously pursue the attack against the decisive point for shock and momentum--create a superiority of morale.

Maneuver is the adaptable commitment of national power resources at all levels of warfare against a responsive enemy in order to gain an ever more advantageous position. The five general concepts which together seem to constitute the principle of maneuver are:

1. Maneuver to obtain mass.
2. Create and use a mobile reserve.
3. Seek the highest possible level of mobility.
4. Minimize the observation, decision, and implementation cycle time.
5. Maintain flexibility of thought, plans, and operations.

The broad definitions of mass and maneuver presented here offer the possibility of considerably more insight into what the nature of space warfare may involve. Certainly, the principle of mass, considered by so many to be so fundamental to understanding the nature of war, should receive careful thought. What would constitute mass in space operations? Based upon the experience of the impact of changing technology upon the principle of maneuver, the application of maneuver to space operations should be particularly challenging. Before this can be done, however, a full conception of the military space force must be realized.

Chapter Five

MILITARY SPACE SYSTEMS

Thus far, the application of the principles of mass and maneuver have been limited by considering only on orbit and possibly reserve spacecraft. However, space systems involve much more than the satellites which are sent into space. Further, space systems are often used in conjunction with each other to perform their various functions within an overall military space architecture. Understanding and using a full system perspective of military space operations is crucial to the development of military space doctrine. Failure to consider the full system will necessarily lead to significant omissions. This chapter presents the four functional areas of space operations, notes that space systems operate in an interdependent architecture creating nodal vulnerabilites, and examines the various segments into which a space system can be divided, all with significant implications for the application of mass and maneuver.

Military space operations involves the complex interaction of all of a nation's space systems within the operational environment. To clarify this concept the following definitions of "space systems" and "the operational environment" are proposed. A nation's space systems include its individual satellite systems, manned orbital systems, launch systems, ground based systems involving space (for example the space surveillance and tracking systems, or ground-to-space weapons), and the organizational structure which provides centralized control and management of the overall system. The operational environment for space forces includes the nation's other military forces (land, sea and air), allied military forces (land, sea, air and space), military forces of the enemy, and the natural environment important to space systems. The breakout of space operations into four functional areas is based upon how space systems operate and apply combat power within this environment.

Space operations are divided into four functional areas--space support, force enhancement, space control, and force application (54:3). The following descriptions of the functions are based upon those contained in the 15 September 1987 draft of Air Force Manual 1-6 (54:118). Space support operations are auxiliary operations conducted to maintain the operations of the systems performing the other three functional areas. Examples would include launch, tracking, and control operations. Force

enhancement functions contribute to the ability of all military forces, including space forces, to carry out their missions. Enhancement operations would include provision of communications, navigation, and surveillance. Space control activities preserve a nation's capability to use the space medium and to deny its use to an opponent. Space control operations include the destruction of enemy spacecraft and the protection of one's own space systems. Examples of space control activities would include the use of an anti-satellite weapon, jamming an uplink on communications satellite, and the destruction by ground forces of a satellite control center. Force application differs in that the combat operations are conducted from space to targets other than space systems. The force enhancement, space control, and force application functions cover the interactions between a nation's other military forces, allied forces, and those of an enemy. The space support, force enhancement, and space control functions describe the way a nation's space force interacts.

A nation's space systems are interactive with each other in several different ways. A single site may provide final assembly, checkout, and mating to a launch vehicle for numerous programs; contain the launch pads of several different types of launch vehicles; and be the only geographical location within a nation to achieve certain orbits. The United States uses two launch sites for orbital operations--Kennedy Space Center and Vandenberg Air Force Base. Both sites support the launch of several different launch vehicles. A similar interaction example is the use of a nation's space tracking and control network to provide tracking, telemetry, and control for many different satellite programs. Most United States military satellites are commanded through the Air Force Satellite Control Facility. A satellite system may provide critical support to another satellite system. For instance, a low resolution surveillance system may provide cloud cover information to a high resolution reconnaissance system. One satellite may relay telemetry and commands to an orbiting satellite. Information from a satellite ground processing station may be transmitted to the end user over a communications satellite system. A ground radar system may be used to verify information from orbiting launch detection spacecraft. Clearly, individual space systems operate within an overall space architecture with some degree of dependency on other space systems.

The dependencies within a space architecture are important from two considerations. First, dependent interactions with other space systems increases an individual space system's vulnerability. The interaction may be so important that negating one system will immediately and totally negate another. A less important interaction may cause the dependent system to gradually degrade over days or months. Secondly, negating those systems which interact with a number of systems throughout the space architecture will have a far reaching effect upon a nation's space capability. The tremendous launch backlog resulting from

the Challenger disaster is a current example. On a smaller scale, however, dependencies occur not only in the overall space architecture, but also within each system.

Satellite systems have been broken down differently into various segments. Giffin proposed the following breakout: satellite, launch system, command and control segment, and user communication segment (11:15-17). The latest draft of AFM 1-6 conceptually uses this same breakout (54:9-12). The latest draft of AFM 2-XK lists three segments, "a control segment; the spacecraft itself, including the launch vehicle; and the communications segment which provides the link between the spacecraft and the using or controlling ground stations" (55:1-2). An earlier draft AFM 2-XK used a space segment, control segment, and user segment with the launch system being considered a separate space system (56:3).

Combining and amplifying these slightly different approaches, satellite systems comprise five segments--a space segment, control segment, user segment, communication links, and a logistics segment. The space segment does not include the launch vehicle, previously considered as a separate space system within the overall space architecture. When multiple systems use the same capability, the shared asset is a separate space system in the space architecture. The equipment, procedures, software, etc. peculiar to a particular satellite system which allows the use of the shared asset, the interface, is allocated to one of the five segments. The simplest to understand of the segments is the space segment.

The space segment is simply all existing spacecraft, to include active satellites, on-orbit "ready-to-use" standby spacecraft, space deployed reserve satellites possibly requiring maneuver before becoming operational, and undeployed spacecraft which have not been launched. Past United States experience in military space operations has allowed only for active satellites. Lt Gen Henry in 1980 explained that production methods and military space budgets did not allow for "spare satellites parked on orbit or spares ready for launch. Hence, we have little depth in our orbital space structure" (27:30). None-the-less, the full range of categories represents possible options for providing depth and flexibility with the space segment. Each individual spacecraft is divided basically into two functional areas.

The two closely interwoven parts of a satellite are the payload and the bus. The payload accomplishes the satellite mission; it performs the functions required by the user. In a communications satellite, the payload consists of the receive and transmit antennas, and the signal processing equipment in between. The user determines specific tasks that need to be accomplished, and then commands the payload as required to complete the tasking. With some systems the user commands the

payload directly with its own command link, while in other systems commands it indirectly by going through the control segment with the tasking. The satellite bus supports the payload. The bus provides the electrical power generation and distribution, physical structure, attitude control system, command receive and telemetry transmission capability, and other required support for the payload. The bus monitors the payload equipment and provides control of the payload by the control segment. The satellite bus is monitored and controlled by the control segment.

The control segment "flies" the spacecraft. It consists of the transmit and receive equipment for the tracking, telemetry, and control links, the processing equipment to interpret the telemetry and generate the commands, the personnel to operate the system, and the organization to manage the system within the space architecture. The control segment interacts with the spacecraft bus through the tracking, telemetry, and control links. Status of the various satellite systems is monitored through telemetry analysis. The required commands for the continued normal functioning of the spacecraft are determined and then transmitted to the satellite for execution. The control segment must continually update the spacecraft's position and velocity information, or ephemeris, and command minor orbit adjustments to maintain the spacecraft's orbit and pointing within its required accuracy. In some systems the spacecraft's time must also be kept within strict tolerance. If the spacecraft is not updated as required the orbit, pointing, and time errors will accumulate to gradually degrade the operation of the payload. In addition to the normal day-to-day "housekeeping" tasks, the control segment solves on-board anomalies. Anomalies may be simple, occur frequently, and thus be resolved easily. On the other hand, they may be extremely complex and require an engineering staff with a complete knowledge of the system and a large facility weeks to solve.

The user segment receives the benefit of the spacecraft by directing the payload, receiving and processing the data received back from the payload, and finally routing the data for its operational use. The user segment consists of the transmit and receive equipment to communicate with the payload or control segment, processing equipment, operators, and communications equipment linking the final processed satellite information to the end user. For a navigation system, the user segment would include the satellite receivers and processors which collect the satellite data, process that data, and then provide the user with current location and velocity information. For a communications system, the user segment would include the transmit and receive terminals, the terminal operators, the communications links to an input/output device, and some kind of a network communications controller to manage assigned communications channels. For a weather satellite, the user segment would include the receive terminal, a station to process the satellite data, and then a

communications link to stations which would make use of the weather data.

The communications links provide connectivity between and within the space, control, and user segments as required. Conventional terrestrial links may provide communications between and within the control and user segments. These links may also be provided by separate satellite communications system. Of special interest are the control and user links with the spacecraft. The control link provides the communication path between the bus and the control segment for transmission of commands and telemetry. The user communications link provides connectivity between the user segment and the payload for payload commands and data. Both the control and user communications path may be either a direct space-to-ground link or an indirect path involving a crosslink to another satellite. A communications satellite represents a special case in that the satellite provides numerous communications channels between the terminals within the user segment. The space-to-ground communications links and crosslinks are characterized by signal strength, bandwidth, central operating frequency within the electromagnetic spectrum, beam width or directionality, and modulation scheme.

The logistics segment provides the supplies and maintenance to sustain the space system's space, control and user segments. The logistics segment acquires and prepares the spacecraft for launch. Future operations may allow for on-orbit repair of failed spacecraft. The logistics segment sustains the equipment and personnel within the control and user segments, just as it does with any other military system. An argument can be made that the logistical support for each segment is really a part of each individual segment. However, breaking the logistical support out from each segment and combining it forces consideration of logistical support for the system as a whole. If left within each segment, there may be a tendency to deal with the operational aspects of each segment, just assuming the segment will continue to operate without considering support requirements. Breaking the logistical support out also forces a recognition of the expected time the space system can operate without any outside support.

Understanding that the operation of a space system depends upon the complex interaction of its various segments is critical in considering how to defeat a particular system. If any of a space system's segments are defeated, the system will degrade and eventually fail. Defeating a system simply means preventing the system from performing its mission to some desired extent. Mission performance may be totally denied or only degraded. Denial of mission performance may be permanent or temporary within a period of conflict. The time it takes for the degradation to occur, and a system's survivability over time, is dependent not only on the survivability of each segment, but on the way in which the segments interact. Complete jamming of a

communications satellite ground terminal by an airborne jammer is an example of a temporary system degradation. Destruction of all of the satellites within a constellation without the capability to replace them during the conflict is an example of a permanent denial (11:25; 12:89-90).

The assets belonging to the space, control, user, and logistics segments are deployed either terrestrially (land, sea or air) or in space. This distinction is important because the threat and weapons effects are different for the terrestrial or ground assets, and the space assets. Normally, the satellites in space are the space segment, and the control and user segments are combined into the ground segment. Giffin for example addressed the means of defeating a space system through the space segment; ground segment; or the command, control, and communications links between the two (11:25). The proposed logistics segment would fall into the ground segment under the usual definition. However, a satellite (space segment) ready for launch in a hardened silo is a ground asset. A manned space station might provide some measure of satellite control for a system (control segment), be the end user of a space communications relay system (user segment), and manufacture unique materials for satellites which cannot be made on earth. The communications links simply retain the same term. The possible threats to the space assets, ground assets, and the communications links must all be considered in an evaluation of space systems survivability.

Giffin's monograph on space system survivability provides a reasonably complete listing of space systems threats by segment. These threats are summarized below from his monograph (11:Chapter 4). Current threats against space segments are spoofing, ground-based directed energy weapons, nuclear and conventional orbital interceptors, and space mines. Space-based directed energy weapons are also possible before the year 2000. The ground segment is vulnerable to sabotage, and direct attack by terrorists, conventional forces, and nuclear weapons. The communications links are vulnerable to electromagnetic interference, exoatmospheric nuclear detonations, and loss of relay satellites.

In addition to presenting the threats against the space system segments, Giffin also presents the ways in which the threats can be countered (11:Chapter 5). Included among the countermeasures to the threats against the space and ground segments is mobility and maneuver. Giffin's conclusion is, "Employing mobile ground stations and satellites with increased maneuver capability can greatly improve the survivability of both the ground and space segments" (11:37). For the space segment Giffin considers both small orbital adjustments and redeployment from higher storage orbits (11:38-39). Under the reconstitution countermeasure Giffin also considers the launch of replacement satellites with survivable deployed launch vehicles, including

mobile launchers (11:42). In the case of the ground segment, Giffin says, "The key strategy for increasing survivability of the ground segment, however, is redundant mobile ground stations" (11:42).

At least two examples of the importance of using a full system perspective of military space operations under even the limited definitions of mass and maneuver previously used are apparent. First, applying the principle of mass, a slightly interactive system's most vulnerable segment represents a decisive point, which if negated can have far reaching impact. Secondly, Giffin's conclusion concerning the mobility of the ground segment indicates that the principle of maneuver for space operations is also extremely important. Garcia's report, "A Strategy for Space Warfare," notes that thus far the principles of war have only been applied to the space segment, and that, " It must be assumed that the principles of war apply to the ground and control segments" (52:39). Clearly, in considering the application of mass and maneuver to space operations, a full system perspective is required.

This chapter has presented a full system perspective which should be used for the application of the principles of war. Space systems interact with other military forces and themselves under the four functional areas of space support, force enhancement, space control, and, potentially in the future, force application. The interaction of space systems is important because the interactions create a greater vulnerability. Where a single system is highly interactive, its negation will have far reaching effects. Each system is composed of a space, user, control, communications link , and a logistics segment, the negation of any one of which will eventually negate the entire system. The interaction requirements between the segments determine how quickly the system will fail after a segment is destroyed. The segments are deployed either in space or terrestrially, with the communications links representing a special case. The threat is different for the space, ground, and communications links. One of the most important countermeasures for the threats against the ground segment was mobility. However, the application of the principles of war thus far has considered only the space segment. Application of the principles of war to space operations must include the user, control, communications links, and logistics segments.

Chapter Six

RECOMMENDATIONS

The work originally begun has yet to be finished. Thus far this report has presented how the principles of war in general might assist in the development of space doctrine. The thoughts to date on the applicability of mass and maneuver were reviewed. In general, both principles are viewed as having very limited application to space operations. The tremendous energy requirements to make even small changes in a satellite's orbit negate maneuver, and without maneuver there can be no collocation of forces. Instead, deployability and pointability replace maneuver, and directed energy weapons are targeted against a common point for mass. However, this view is based using too limited a definition of both mass and maneuver, applying the principles only to the space segment, and limiting the space theater of war to only the near earth orbits used today. A major problem unforeseen in this effort was the need to develop full definitions of the principles of mass and maneuver which would account for the variations seen among the many theorists and levels of warfare. Under comparative analysis both the principles converged into five concepts each. Finally, the composition, functioning, and vulnerabilities of space forces were examined so that all aspects of space operations would be considered for the application of mass and maneuver. What remains is to first summarize the space theater of war beginning with Stine (19:--) and Vaucher (21:--). Then each of the five concepts of mass and maneuver should be applied to the use of space systems under the strategic, operational, and tactical levels of warfare.

The comparative analysis of mass and maneuver among the various theorists produced a comprehensive definition of each that indicates more fully how the principle is applied at the different levels of war. A comparative analysis of the other principles of war should also be performed. Such a complete analysis would make the principles of war a far more valuable tool in understanding warfare.

Finally, assuming such a comparative analysis of the principles of war was made, the results would have to be incorporated into our doctrine. This would include not only space doctrine, but the organizational, environmental, and fundamental doctrine of all the services. Both the Army's FM

100-5 (46:--) and the Air Force's AFM 1-1 (42:--) would be included.

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APPENDIX

Principles of Mass and Maneuver from AFM 1-1

The definitions of mass and maneuver from the 1979 and 1984 editions of Air Force Manual 1-1 are quoted below in their entirety:

MASS [1979 edition]

Aerospace forces can be rapidly concentrated at a critical time and place, to produce decisive results. Mass can be achieved by using deception, speed, and maneuverability. Aerospace forces, based in widely dispersed locations, can be rapidly concentrated to deliver required firepower against selected targets before an enemy can react. Air forces can arrive at an objective at a given time while maintaining an overall economy of force (43:5-5).

MANEUVER [1979 edition]

War is a complex interaction of moves and counter moves. By maneuver commanders seek to employ their strength selectively against the enemy's weakness and, when practical, to avoid an engagement when confronted by an enemy force of superior strength. Commanders at all echelons should recognize that avoidance of battle in the face of bad odds may not be possible--nor sometimes desirable in relation to the overall strategy.

Maneuver is required to maintain the initiative, dictate the terms of the engagement, and to conduct offensive operations. The use of maneuver allows commanders to position their forces in places and at times that surprise the enemy, so that the enemy forces are unable to counter or respond effectively.

While maneuver is essential, it is not without risks. To move large forces is to invite loss of cohesion. Therefore, commanders must strive to retain the cohesion of their forces with the least possible reduction in the tempo of action. To be effective, maneuver requires precise execution and timing, concentration of force, and adequate logistic support (43:5-7)

[MASS from 1984 edition]

Success in achieving objectives with aerospace power requires a proper balance between the principles of mass and economy of force. Concentrated firepower can overwhelm enemy defenses and secure an objective at the right time and place. Because of their characteristics and capabilities, aerospace forces possess the ability to concentrate enormous decisive striking power upon selected targets when and where it is needed most. The impact of these attacks can break the enemy's defenses, disrupt his plan of attack, destroy the cohesion of his forces, produce the psychological shock that may thwart a critical enemy thrust, or create an opportunity for friendly forces to seize the offensive (42:2-7)

[MANEUVER from 1984 edition]

War is a complex interaction of moves and countermoves. Maneuver is the movement of friendly forces in relation to enemy forces. Commanders seek to maneuver their strengths selectively against an enemy's weakness while avoiding engagements with forces of superior strength. Effective use of maneuver can maintain the initiative, dictate the terms of engagement, retain security, and position forces at the right time and place to execute surprise attacks. Maneuver permits rapid massing of combat power and effective disengagement of forces. While maneuver is essential, it is not without risk. Moving large forces can lead to loss of cohesion and control (42:2-7).

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